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House Bill HR 3197 Secure Handling of Ammonium Nitrate Act of 2005

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ABOUT THE AUTHOR

Dr. Oxley is Professor of Chemistry at the University of Rhode Island. Her field of research is the study of explosives and other energetic materials. She has studied the behavior of most explosives, but ammonium nitrate (AN) she has examined from the milligram to the ton scale. Dr. Oxley has worked with various military laboratories and law enforcement agencies in the U.S. Over the last decade, she has worked with the British Forensic Explosive Laboratory (dstl)[1] on projects ranging from attempts to inert ammonium nitrate to those examining ways to enhance its explosive potential.

GENERAL COMMENTS ON CHEMICAL EXPLOSIVITY

For a chemical to be an explosive it must undergo a rapid, self-contained, chemical reaction that releases energy and heat. Most explosives achieve this by oxidation. Oxidation produces heat and gas, generally carbon dioxide or monoxide and water. The detonation gases do the work of an explosive. Explosive power comes from the rapidity of the reaction that supports the detonation wave. Although burning is also oxidation resulting in heat and gas, the reaction is too slow to create a detonation wave. Explosives can sustain rapid oxidation because they contain their own oxygen—either as part of the molecule, as in military explosives (TNT, RDX, PETN)[2] or in intimate mixtures of oxidizers and fuels, as in composite explosives such as ammonium nitrate (AN) with fuel oil (FO).

The number of potential oxidizers for use in composite explosives is large, but practical considerations, i.e. availability, limit the potential threat. The number of potential fuels, however, is nearly limitless--combustible non-explosives, e.g. rosin, sulfur, charcoal, coal, flour, sugar, oil, paraffin as well as fuels that are explosive in their own right, e,g, nitromethane and hydrazine. To date terrorists have used fuel oil (ANFO) or icing sugar (AN/S) in combination with AN.

While chemical make up is important, the configuration of the explosive device is also critical. Rapid energy release is necessary to "support" the detonation front, much like a piston; therefore, the configuration of the chemical must be such that the wave is not quenched by dissipation at the edges of the device.[3] The concept of "critical diameter" addresses the limit where the explosive charge is too small to support a detonation wave. Thus, 200g of a military explosive in a cylindrical configuration is probably detonable; but the same amount of that material sprinkled across a table top is probably not.

Most military and composite explosives require a detonator, made of highly sensitive explosive, to initiate a detonation. In addition, composite explosives, being particularly insensitive, often require a booster and a detonator to initiate.[4] In the past, these requirements restricted who could make explosive devices to those who could acquire detonators and boosters by theft or good black-market contacts. Nowadays, most terrorists and some teenagers are aware that the solid peroxide explosives can be readily used in this capacity.

CONCLUSIONS AND RECOMMENDATIONS

1. Availability of a material is a major factor in its use by terrorists. Creating a bomb from military explosives requires theft of the explosive; black-market connections to purchase the explosive, or a skilled synthetic chemist and lab facility. Composite explosives require as little as stirring the oxidizer and fuel together. Either type of bomb requires acquisition of detonators, and composite explosives usually require boosters, as well. The availability of all these factors dictates the nature of the explosive device.

Fuels are ubiquitous, and oxidizers are widely available, having major roles in purification and bleaching. It is likely that a number of oxidizers, on a sufficiently large-scale, could be formulated into composite explosives. The terrorist choice is, to a large degree, governed by regional availability.

Terrorist use of ammonium nitrate (AN) began in the bombing campaign of the Provisional Irish Republican Army (PIRA) (1969 to 1994). During that period there were 14,000 bombing incidents, most involving commercial explosives or sodium chlorate/nitrobenzene. At the peak of the campaign in the early 1970's, the British government issued a ban on the sale of chlorate, nitrobenzene, and pure AN in Northern Ireland. Nevertheless, large AN fertilizer bombs were used in the City of London. Approximately 1000 pounds were used at St Mary le Axe (April 1992) and about 3000 pound at Bishops Gate (April 1993). In other countries, AN has been used less frequently in terrorist bombings; a notable exception were the African embassy bombings (Aug. 7, 1998). In the United States (U.S.) about 18 billion pounds of AN are produced annually. Of that, about 5 billion pounds are made and used for commercial explosives; the rest goes to the fertilizer market. Because the preparation of AN explosives is straightforward and well-known and because the bombing of the Murrah Federal building (Oklahoma City, April 1995) was devastating, the U.S. followed the British in funding research attempting to desensitize AN. No outstanding successes have been reported from that effort though, at a modest level, research continues.

In Israel, where sales of solid AN are prohibited, rather than evaporate the water from commercially available AN solution, terrorists have chosen to use urea nitrate. For a number of years, urea nitrate has been a favorite of Arabic terrorists. It was used in the bombing of the World Trade Center (Feb. 1993). Urea intended to be made into urea nitrate was brought across the U.S.-Canadian border by the would-be millennium bomber Ahmed Ressam. The Shining Path used urea nitrate so frequently in bombings that in 1992 sales of urea were banned in Peru.

Potassium chlorate, like AN, is one of the few oxidizers readily available in bulk. In the U.S. 1.2 billion pounds of chlorate salt are used annually by the pulp and paper industry and agriculture. Before AN became the oxidizer of choice in large charges, chlorate was used. Replaced by AN for large devices, it continued to be recommended in the "do-it-yourself" literature for use in small, anti-personnel devices. The Bali bombing (Oct. 12, 2002) once again demonstrated its explosive potential on a large-scale.

Dozens of peroxide compounds are used as free-radical initiators by the polymer industry or in bleaching processes. Although a degree of hazard is associated with the handling of most peroxides, TATP and HMTD are unusual in that their three peroxide functionalities give them explosive potential. TATP has about 88%, and HMTD, about 60% of TNT blast strength.[5] The unusual danger in these peroxides is not their blast strength; it is their ease of initiation (due to the peroxide linkage) and the ease with which terrorists have acquired and used the materials for their synthesis. Richard Reid, the would-be shoe bomber, intended to use TATP to initiate a PETN charge (Dec. 2001). HMTD was prepared and carried into the U.S. by Ahmed Ressam with the intention of using it to initiate urea nitrate bombs (Dec. 1999). Peroxide explosives have also been used as the main charge (e.g. the London bombings of July 2005 and countless suicide vests and car bombs in Israel). These solid peroxides require a special degree of skill to synthesize successfully and safely. In contrast, concentrated hydrogen peroxide can be used without synthesis. The aborted bombing in Karachi (Mar. 15, 2004) suggest that terrorists are well aware of its potential.

Recommendation: ***There should be a worldwide survey of availability of oxidizers, and methods of tracking purchase and transport of large quantities of oxidizers should be developed.*** Such information would highlight unusual patterns of activity and aid in predicting and preventing incidents.

2. Only large-quantities of oxidizer need be considered a threat.
Because AN formulations tend to be insensitive a fair amount is required to support detonation.[3] Briefcase bombs of ANFO have not been used, rather AN is formulated into effective car or truck bombs. To make an AN-based device, the formulator must have large quantities of AN and also means to initiate and boost it. It is wasted effort and masks the important data to track every small sale of AN. The British in their various regulations[6] have addressed the quantity issue in terms of "sufficient material to have an explosive effect" or in quantities greater than "1 tonne."

Recommendation: ***There should be a lower limit on the amount of oxidizer of concern in this legislation.*** Not only does it require Herculean effort to detonate AN on a small-scale, but in the U.S. the widespread availability of smokeless and black powders makes them more likely candidates for small bomb construction.

3. ***Tracking purchasers of bulk oxidizer is a modest step toward restricting illegitimate use***. Countermeasures are obvious. Credit card companies already have a start on the problem of fraudulent use.

Recommendation: ***Require credit card purchase for large quantities (e.g. 1 ton) of oxidizer.*** This makes use of some of the built-in checks and information found in credit cards.

4. ***International collaboration should be sought.***

Recommendation: ***The British have faced a serious AN threat for over two decades. Open dialog between all levels working on this problem.***

5. ***Consider other potential threat materials.*** Once one material becomes harder to obtain, others may be substituted.

Recommendation: ***Consider the explosive potential of large quantities of oxidizers and other energetic, non-explosives***. D***evelop better methods to indicate potential explosivity of large quantities.*** The Department of Transportation (DOT) Test Series 1 is used to classify chemicals as explosive or non-explosive for purposes of transportation.[7] However, the DOT test series uses no more than 2 pounds of the candidate material. Tested on that scale, AN and other materials pass as non-explosives. Tested on a larger scale, some detonate. In general, materials which require ton-quantities to detonate do so at low (30-40%) TNT equivalencies.[5] Nevertheless, many such chemicals with one third TNT equivalence of 3000 tons is 1 kiloton TNT equivalence.

6. ***Exempt explosive-grade AN from this legislation.*** Some grades of AN are classified as explosives under DOT regulations because of their specific chemical and physical properties.

Recommendation: ***The bill needs a clause to specify that any grades of AN that are classified as explosives under DOT regulations will continue to be controlled under the existing and stricter explosives regulations*** rather than this new law aimed at control of fertilizer-grade AN.

FOOTNOTES

1. dstl is a British government at Fort Halsed--Defense Science and Technology Laboratory.

2. TNT 2,4,6-trinitrotoluene; AN ammonium nitrate; PETN pentaerythritol tetranitrate; HMX octahydro-1,3,5,7,-tetranitro-1,3,4,5-tetrazocine; RDX hexahydro-1,3,5-trinitro-s-triazine; HMTD hexamethylene triperoxide diamine; TATP triacetone triperoxide. RDX is the active ingredient in C4; PETN is the active ingredient in sheet explosive and most detonating cord.

3. A shock wave traveling through an explosive charge will be reflected at the edges of the charge where it hits a high-density region (much like water hitting the wall of a swimming pool). The reflected waves (rarefaction waves) degrade the shock wave, so that at such edges the wave is slowed and an overall curvature of the wave develops. If the diameter of the explosive is narrow, the rarefaction waves may be sufficient to kill the shock wave. The minimum diameter at which an explosive can support detonation is termed the “critical diameter.”

4. To detonate an explosive charge, a detonator containing a “primary” explosive, sensitive to mild stimulation (impact, friction, heat), is used to create a shock wave. This shock wave is directed into the “secondary” explosive, the main charge. In military devices the secondary explosive (e.g. TNT, RDX, HMX, PETN or formulations thereof) is sufficiently insensitive that it can be initiated only by such a shock wave. Most AN formulations are even more insensitive than military explosives. They require an amplification of the shock wave from the detonator; thus, a booster, a secondary explosive, is placed between the detonator and the AN charge.

5. “TNT equivalence” is a rough method of comparing explosive power. Often, it is obtained by comparing the blast pressure of an explosive charge to that of the same amount of TNT with all other factors being held equal.

6. See documents at Internet site http://www.hse.gov.uk/explosives/ammonium.

7. “Recommendation on the Transport of Dangerous Goods: Manual of Tests and Criteria,” 3rd ed. United Nations, N.Y. 1999.